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# Extending Remote Experimentation Environments to Support Visual and Audio Impaired Users

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**Abstract**—Remote experimentation provided as part of a web-based learning approach affords a number of critical benefits, allowing flexible access to campus based laboratory resources. Increasingly, educational institutes are offering remote experimentation environments which allow users to undertake courses in practical engineering disciplines remotely controlling and manipulating laboratory instrumentation and equipment. The degree of functionality and level of user access to remote laboratory environments has evolved greatly expedited by advances in web technologies and applications. Recently the provision of web based environments which accurately recreate the lecturer-led and group working experience of traditional on campus based laboratories have been explored. These environments unify the online lecture and lab experiment aspects of e-learning to provide a comprehensive media-rich, highly interactive and engaging experience. However the majority of current remote experimentation environments fail to cater for users with disabilities e.g. visual or audio impairments. This paper will present a case study on the ProculTech remote experimentation environment which explores the issue of usability and accessibility in this context and illustrates how to create appropriate interfaces which will enrich the learning experience of visual/audio impaired users.

**Index Terms** — Usability, accessibility, enhanced learning environments, remote collaborative experimentation.

## I. INTRODUCTION

There are a significant and increasing number of education institutions and professional development organisations now offering courses and degree programs via e-learning. The University of Ulster, N. Ireland in particular advertises to potential students via its ‘Campus One’ e-learning division, with over 200 courses on its website ranging from Information Technology to Construction studies. Students can complete these courses remotely via access to traditional online media and delivery formats. The advantages of online learning are evident but for students with disabilities the material is often presented in a format which can be difficult to view or interpret (e.g. audio). In a study of over 200 environments and web sites from several leading e-learning providers it was revealed that almost 75% of sites had high levels of inaccessible material and pages [1]. It is essential that the needs of all users, regardless of physical capabilities are catered for in the design of online learning resources. To address these issues, all

online teaching materials must be designed using best practice related to usability and accessibility.

The demand for e-learning courses poses unique challenges for disciplines involving high levels of practical work. For electronic and electrical engineering disciplines hands-on experience is essential for effective learning [2]. The traditionally on campus laboratory experience restricts access to resources to normal working hours which does not meet the needs of university students requiring more flexible attendance patterns in line with current lifestyle commitments. Remote experimentation facilities offered as part of a web-based learning approach enable remotely located users to complete lab assignments unconstrained by time or geographical considerations facilitating the development of highly practical skills in the use of real systems/instrumentation. Currently there are several environments available which support the access to remote labs where practical experiments can be completed and key practical skills developed. The ProculTech environment developed by the University of Ulster extends the current trend of single user environments to accurately recreate the group-working experience of traditional on-campus based laboratories [3]. However, issues pertaining to the usability and accessibility of users in the context of remote experimentation environments have not been fully investigated to date. To support users with disabilities such as visual and audio impairments requires the development of remote access environments which can accommodate the delivery of tailored content and experiment interfaces. This paper will present a case study on the ProculTech remote experimentation environment and will illustrate how to create appropriate interfaces which enrich the learning experience of users who suffer from visual/audio disabilities. Section 2 will present the ProculTech environment and section 3 will highlight the strategies to support appropriate interfaces. Section 4 and 5 will provide a case study on how the interfaces were adapted to the ProculTech environment and a summary on the feedback from disabled users who evaluated the environment.

## II. PROCULTECH ENVIRONMENT

The ProculTech e-learning environment was developed by the Intelligent Systems Research Centre of the University of Ulster, Northern Ireland and provides remote-access to laboratories on embedded systems

modules on a range of undergraduate and postgraduate courses. The facilities in the environment complement existing course provision by enabling students to conduct practical experiments in this subject area remotely via the Internet. In particular, the environment supports collaborative working as students will typically work in groups to complete experiments, mentored and guided in this process by lecturers and support staff. The environment attempts to accurately recreate this aspect of the on-campus laboratory experience and allow remotely located users to work together on the same experiment hosted on the same remote workstation, simultaneously, while accessing, viewing and controlling each element of the learning environment, e.g. lecture video, webcams of circuits with LED lights, instrumentation, remote desktop viewer. For example any changes made by one user to any of the components of the environment are immediately replicated to all users. Fig.1 provides an overview of the ProcuTech environment showing a tabbed system allowing for easy navigation between the various elements (lecture material, remote desktop viewer).

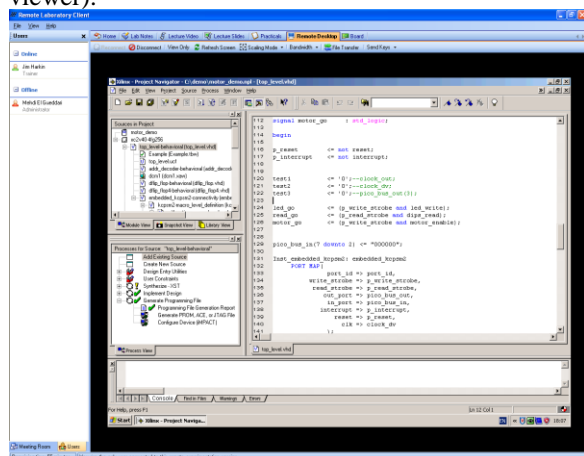


Figure 1. ProcuTech Environment – remote desktop viewer

## III. USABILITY AND ACCESSIBILITY

The ability of users to access remote experimentation resources and use the information provided to conduct experiments is difficult if the information cannot initially be interpreted or understood. For example if the lecture video which displays the tutor discussing the various steps or procedures of an experiment cannot be understood audibly, a user could potentially become confused as to the objective of the experiment or what steps are required to complete the experiment. Users with audio impairments often experience this confusion and frustration with e-learning material where the media content is only tailored for non-disabled users. Often such users have increased awareness of their visual surroundings than someone with full hearing ability, and typically communicate through the use of sign language, e.g. the British Sign Language. This is a visual language which can be used to aid the users in the learning experience. Similarly, those users with visual impairment who are partially sighted or suffer from colour blindness

often experience text which cannot be read or different colours which they cannot distinguish [1]. Often text to speech software or image/symbols are used instead of text to convey the same information. These issues are proliferated in the context of remote experimentation where video lectures are often used to explain the steps required to complete an experiment, and the colours of LEDs/instruments to convey feedback on experiments. To initially address these usability issues it is proposed to incorporate the use of sign language with video lectures and to replace visual icons such as LEDs with symbols/images.

## IV. CASE STUDY - PROCUTECH

The ProcuTech environment is used as a case study to illustrate the modifications required by environments to enable the support of users with audio impairments and partial sight. The additional usability features outlined in section 3 were incorporated into the ProcuTech environment as shown in Fig. 2. The tool bar located at the top of the environment also enables users to select additional modes including *sign-only*, *subtitles* or *sign and subtitles*. The depicted figure (in *sign-only* mode) shows the inclusion of sign language to support users with audio impairments where the dialogue spoken by the recorded lecturer is replicated by a sign-language tutor in another recorded video. In addition, the LEDs used in the environment were also replaced with symbols to indicate when they were turned on or off..

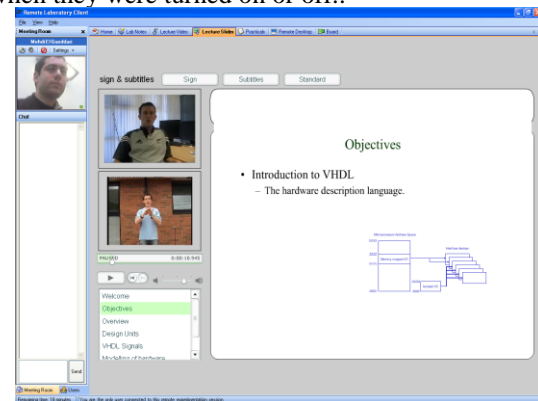


Figure 2. ProcuTech Environment – sign language supported

## V. CONCLUSION

The paper presents a case study on the ProcuTech environment which was appropriately modified to address the needs of users with disabilities.

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